Effect of Temperature on Efficacy of *Theocolax elegans* (Hymenoptera: Pteromalidae) to Suppress *Rhyzopertha dominica* (Coleoptera: Bostrichidae) in Stored Wheat

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Introduction

Biololgical control is an overlooked component of integrated pest management of stored grain. Most of the parasitoids that attack the primary beetle pests are in the families Pteromalidae and Bethylidae. These hymenopterous parasitoids are very small (1-2 mm), and do not feed on the grain. They will normally die or leave the grain within 5 to 10 d if no beetles are present in the grain. These parasitoids are found naturally in stored grain, which suggests that once released they may continue to suppress pests for many years (Sinha et al. 1979). Because the adult wasps are external to the grain, they can easily be removed from it using normal cleaning processes.

The lesser grain borer, *Rhyzopertha dominica* (F.), is one of the most common and damaging insect pests of stored wheat in the United States (Storey et al. 1984). Adults feed primarily on the wheat endosperm and cause considerable damage. *R. dominica* larvae develop within the grain kernel and cannot be removed from the grain by normal cleaning procedures.

Theocolax elegans (Westwood) is a small pteromalid wasp that attacks the coleopterans *R. dominica*, *Sitophilus* spp., *Stegobium paniceum* (L.), *Callosobruchus* spp., and the lepidopteran, *Sitotroga cerealella* (Oliver) (Burks 1979). This wasp normally parasitizes larvae that are feeding inside the grain kernel. Although wasp larvae can complete development on 3rd instar and prepupal *R. dominica*, larval survivorship is highest when laid on 4th instar *R. dominica*. They normally lay 1 egg externally on each host (Sharifi 1972). If more than 1 egg is present, only 1 larva completes development. At 32°C, it takes about 15 d to complete development on *R. dominica*. The generation time of this wasp is about half that of *R. dominica*. If hosts are available, female wasps live for 10 to 20 d at 32°C. A single female *T. elegans* can parasitize up to 6 *R. dominica* per d. In a previous field study, Flinn et al. (1996) showed that *T. elegans* was very effective in suppressing *R. dominica* in 27 t bins of stored wheat. *R. dominica* populations were suppressed by over 91% in relation to control bins.

Biological control can be more effective when used in conjunction with other control methods. In stored grain, one of the most effective nonchemical control methods is to cool the grain with aeration fans. Aeration, using electric powered fans, is used to cool the grain earlier; thus it suppresses insect population growth sooner in the storage period (Flinn et al. 1997). Under typical summer conditions in Kansas, automatic aeration controllers will reduce the grain temperature from 32°C down to approx.25°C.

In this study, I investigated the effects of two temperatures, which simulated unaerated and summer aeration of wheat, on the ability of *T. elegans* to suppress *R. dominica* population growth.

Materials and Methods

Experiments were conducted in twelve 22.7 liter cylindrical plastic pails (38 cm tall by 31 cm diameter). The containers had tight fitting snap-on lids, with a 21 cm hole covered with 122-mesh polyester silk-screen. The containers were filled with 19 kg of hard red winter wheat (12% moisture). Two adult female and 2 adult male *R. dominica* beetles were placed in each container. The adults were obtained from a laboratory culture and were approx.1 wk old. Six of the containers were placed in an environmental chamber maintained at 32±1°C and 65±10% RH, and 6 were placed in an environmental chamber maintained at 25±1°C and 65±10% RH. After 20 days, 2 adult male and 2 adult female *T. elegans* wasps were placed in 3 of the containers in the 32°C chamber. The wasps were obtained from a laboratory culture and were approx.2 d old. Ten days later, 2 adult male and 2 adult female *T. elegans* were placed in 3 of the containers in the 25°C chamber. *T. elegans* prefers to parasitize 4th instar *R. dominica*. Therefore the parasitoids were released 10 days later in the 25°C than in the 32°C chambers so that stadiums 1-4 would be available in containers in both chambers.

Sixty three days from the initial beetle release, 9 grain samples, each approx.45 g, were taken in each container using a miniature grain probe (Flinn and Hagstrum 1995). The containers were sampled every 2 wk up to 161 d from the initial beetle release. The samples were sieved and insects counted.

Results and Discussion

Suppression of *R. dominica* population growth by *C. elegans* was much greater at 25 than at 32°C. After 161 d of storage, *R. dominica* density in the containers with *T. elegans* was 10/kg at 25°C and 9,185/kg at 32°C (Fig. 1a,b).

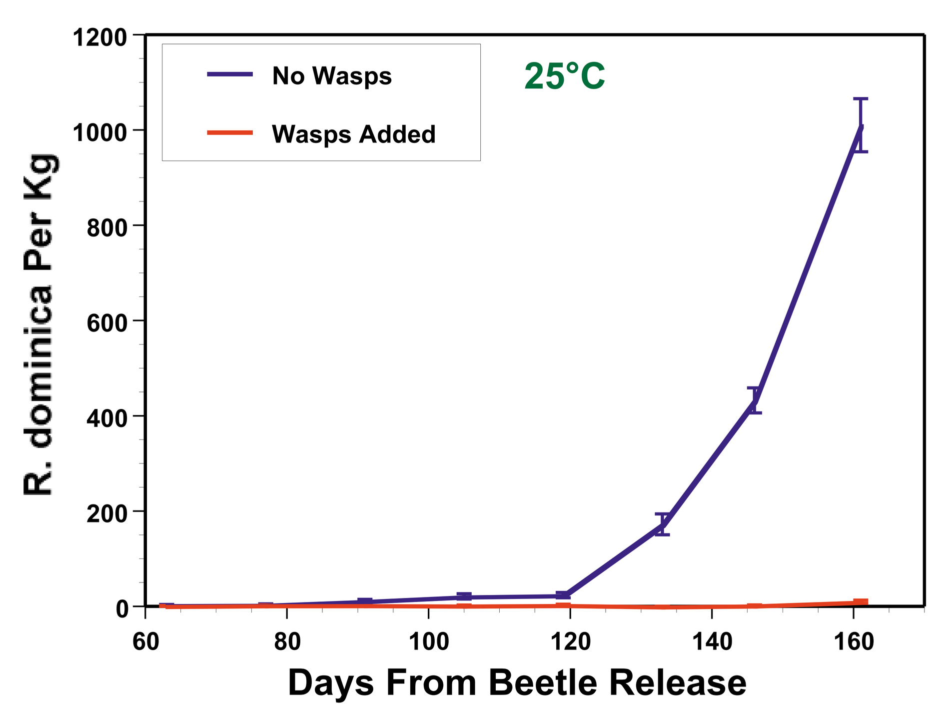

Fig. 1a. Mean *R. dominica* density in containers with 19 kg of wheat with and without *T. elegans* added at 25°C. Vertical bars indicate SEs of the mean.

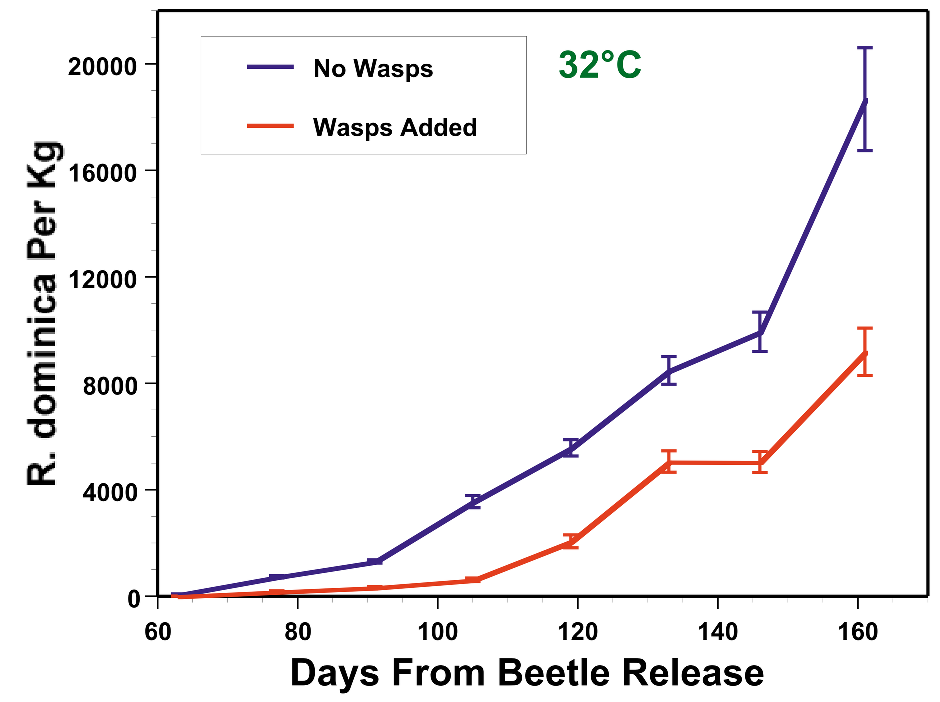

Fig. 1b. Mean *R. dominica* density in containers with 19 kg of wheat with and without *T. elegans* added at 25°C and 32°C. Vertical bars indicate SEs of the mean.

At 32°C, there were significant differences in mean *R. dominica* density between containers with and without *T. elegans* at each sampling date. At 25°C, there were significant differences in mean *R. dominica* density between containers with and without *T. elegans* at each sampling date, except for the first two sampling dates. Population growth of *R. dominica* was also suppressed by lower temperature alone. After 161 d of storage in containers without *T. elegans*, *R. dominica* density was significantly greater in containers held at 32°C than at 25°C (18,673/kg at 32°C and 1,010/kg at 25°C).

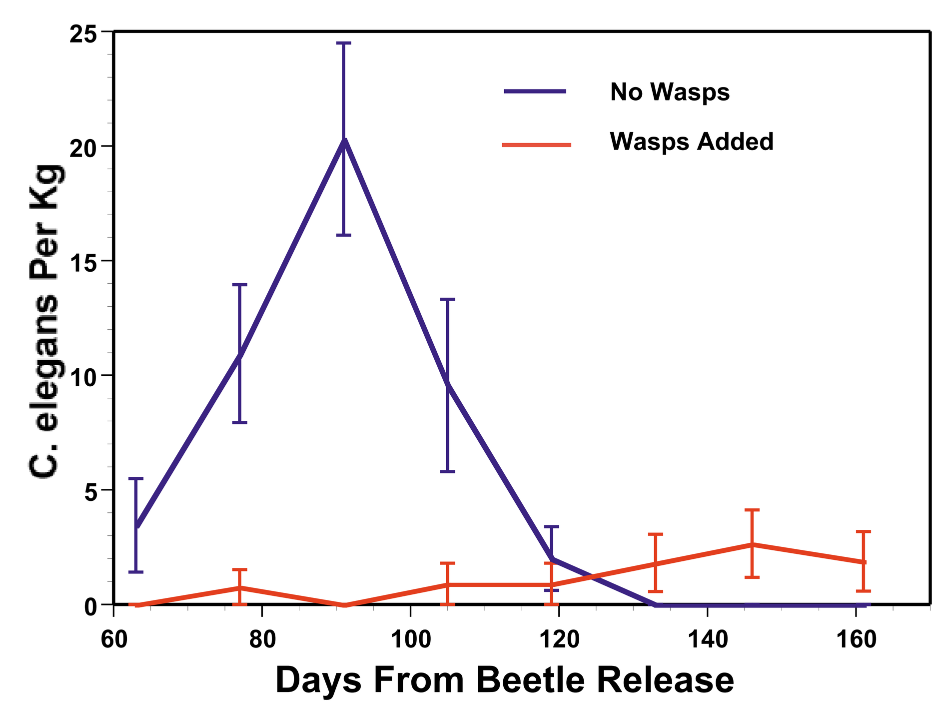

Fig. 2. Mean *T. elegans* density in containers with 19 kg of wheat with and without *T. elegans* added at 25°C and 32°C. Vertical bars indicate SEs of the mean.

T. elegans reached greater densities in the containers held at 32°C than at 25°C (Fig. 2). At 32°C, *T. elegans* reached a peak of 20 insects per kilogram after 91 d. However, after 133 d, very few *C. elegans* were found in the 32°C containers. After 105 d at 32°C, beetle density in the containers with *T. elegans* reached an average of 616/kg. This is a very high beetle density, and may have suppressed wasp population growth by interfering with parasitization. At 25°C, *C. elegans* increased steadily to a maximum density of 3/kg after 146 days.

In general, the percentage reduction in *R. dominica* density caused by *T. elegans* was greater at 25°C than at 32° (Fig. 3). After 133 d, percentage reduction decreased to appox. 50% in the containers held at 32°C and increased to 99% in the containers held at 25°C treatment. At 25°C, *T. elegans* may have been able to locate and parasitize most of the larvae that were produced by the original *R. dominica* adults, and this resulted in a very high level of population suppression. In contrast, at 32°C, *T. elegans* may have been unable to locate and parasitize most of the beetle larvae. At the warmer temperature, the beetles had a higher oviposition and developmental rate, and thus the number of beetle larvae *T. elegans* would need to parasitize to prevent *R. dominica* population growth would be much higher. Because *C. elegans* does not attack adult beetles, as the number of unparasitized *R. dominica* larvae that developed into adults increased, the ability of *C. elegans* to suppress the population would diminish. Although *C. elegans* population growth rate is also higher at 32°C, their ability to find and parasitize most of the 4th instar *R. dominica* larvae may not be greater at the higher temperature.

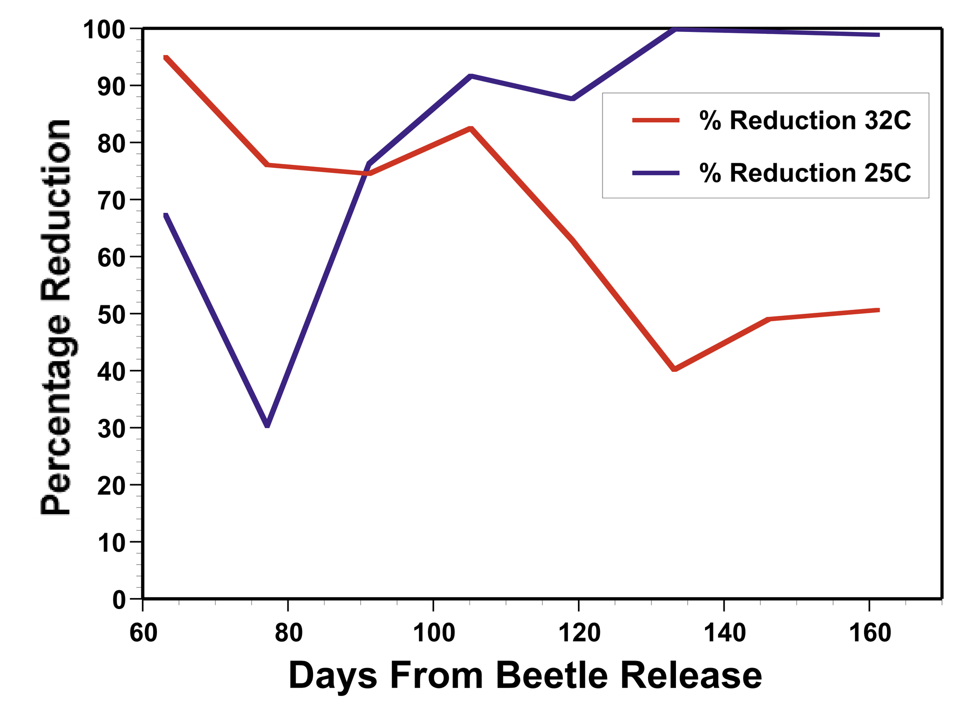

Fig. 3. Percentage reduction of *R. dominica* at 25 and 32 C caused by *T. elegans* in relation to the absence of *T. elegans* at each temperature.

When augmentative parasite releases are made with *T. elegans*, this study suggests that better *R. dominica* suppression would be achieved by cooling the grain with aeration as soon as it is put in the bin. Even when augmentative releases are not used, reducing the grain temperature with early aeration will suppress *R. dominica* because of decreased population growth at lower temperatures. In addition, because natural populations of *T. elegans* are often found in grain bins, lower temperatures will help these natural populations to suppress *R. dominica*.

SUMMARY

Laboratory studies were conducted to assess the effectiveness of the parasitoid wasp, *Theocolax elegans* (Westwood) for controlling *Rhyzopertha dominica* (F.) (lesser grain borer) in wheat at 32 and 25°C. The two temperature regimes were used to simulate an unaerated bin of wheat and a bin aerated at harvest time. Two adult male and two adult female *R. dominica* were each released into containers with 19 kg of hard red winter wheat. An equal number of adult *T. elegans* were released into half of the containers. Half the containers were kept at 25°C and half at 32°C. Suppression of *R. dominica* population growth by *T. elegans* was much greater at 25 than at 32°C. After 161 days, *R. dominica* density in the containers with *T. elegans* was 9,185/kg at 32°C, and 10/kg at 25°C. At 25°C, *T. elegans* was able to locate and parasitize most of the larvae that were produced by the adult beetles. This resulted in a very high level of population suppression (99% in comparison to the control at 25°C). In contrast, at 32°C, beetle suppression was only 50% in comparison to containers without *T. elegans* at this temperature. This study suggests that when augmentative parasite releases are made with *T. elegans*, better host suppression would be achieved by cooling the grain to 25°C shortly after harvest, rather than leaving it unaerated for the summer.